The Calibration of AVHRR/3 visible dual gain using Meteosat-8 as a MODIS calibration Transfer Medium

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2007 CALCON Technical Conference

Logan, UT, September 10-13, 2007

Motivation

- Climate Absolute Radiance and Refractivity Observatory (CLARREO) Mission - designed to calibrate other imagers
  – put calibration resources into CLARREO, imagers can focus on mission requirements and can use CLARREO as a calibration reference
  – Employs radiometers requiring a footprint of 100km in order to spectrally resolve the shortwave radiance.
- AVHRR/3 employs a dual gain in the visible
  – No onboard visible calibration
  – GAC has global coverage and is a 3x5 km subset of the HRPT
    - No special operations needed, when matching to a 100km FOV
- To transfer the CLARREO calibration to AVHRR/3 the dual fit must be solved simultaneously
  – Both high and low counts will be present in a 100km FOV

Methodology

- Use MODIS as the calibration reference
- MODIS and AVHRR/3 coincident visible matches occur at 70°N latitude
  - Only during June and July is there enough of a high count dynamic range to effectively calibrate the high counts
- Use Meteosat-8 as a calibration transfer medium
  - Equatorial matches ensures bright targets to resolve high gain
  - Meteosat-8 has all 3 AVHRR/3 visible channels
  - Calibrate Meteosat-8 with MODIS
  - Calibrate AVHRR/3 with Meteosat-8
- Develop statistical package to derive dual gains
  - Verify space count, break point continuity, gain ratio
  - Monitor gains over time for degradation and monthly gain noise

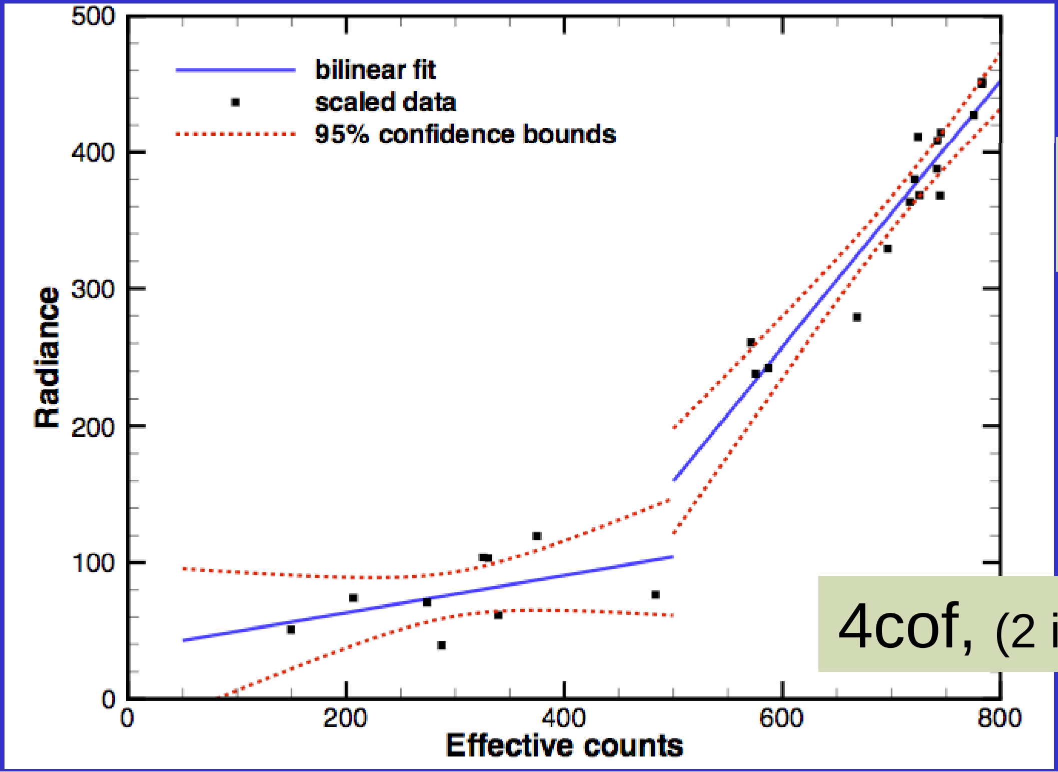
Dual Gain Regression Methods

- Constant space count (SPC) or determine offset (OFF)
  - AVHRR incorporates a space clamp
- Low gain tied to high gain (TIED) or dual gains (DUAL)
  - There is one detector and optics, high gain a multiple of low gain
- Continuous breakpoint (CONT) or gap between high and low counts (GAP)

SPC TIED CONT 1COF	SPC TIED GAP 2GAP	SPC DUAL GAP 3SPC	OFF DUAL GAP 4COF
	SPC DUAL CONT 2DUAL	OFF TIED GAP 3TIED	
	OFF TIED CONT 2OFF	OFF DUAL CONT 3CONT	

Example of Regression methods

- Randomly generate GAC pixel counts in 50 km FOV using prescribed space count, no gap, and tied gains
- Calculate 95% confidence limits for each method

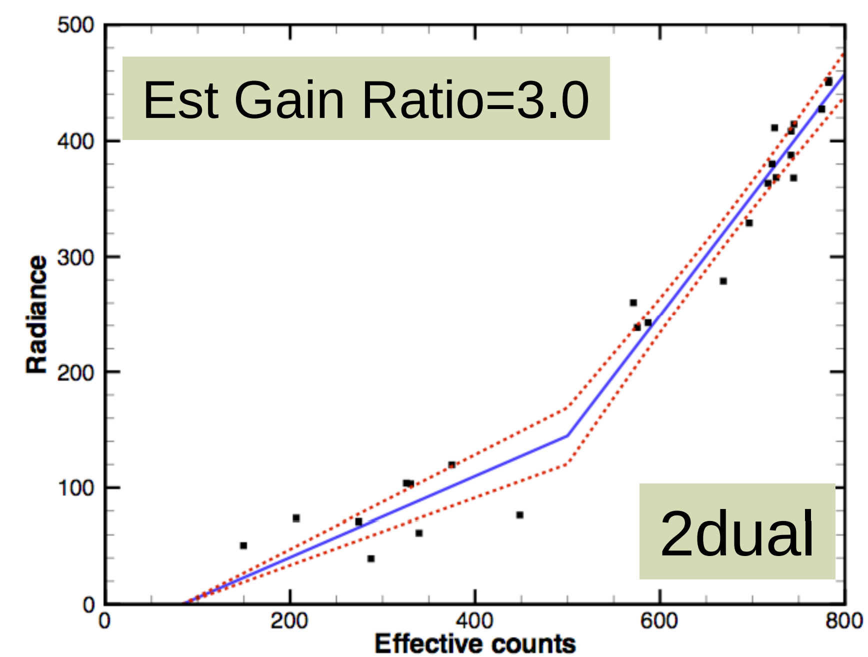


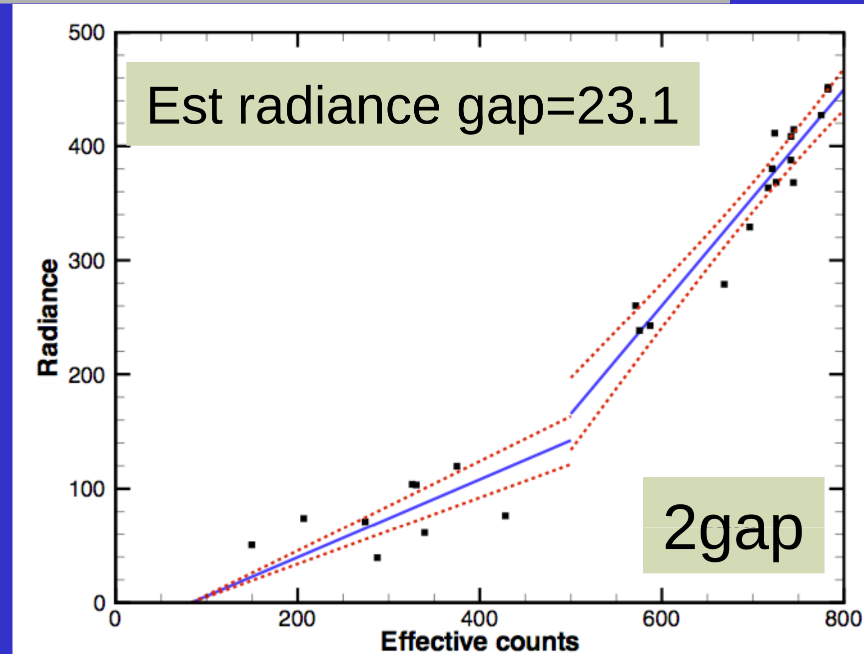
• Each point represents a 50 km FOV

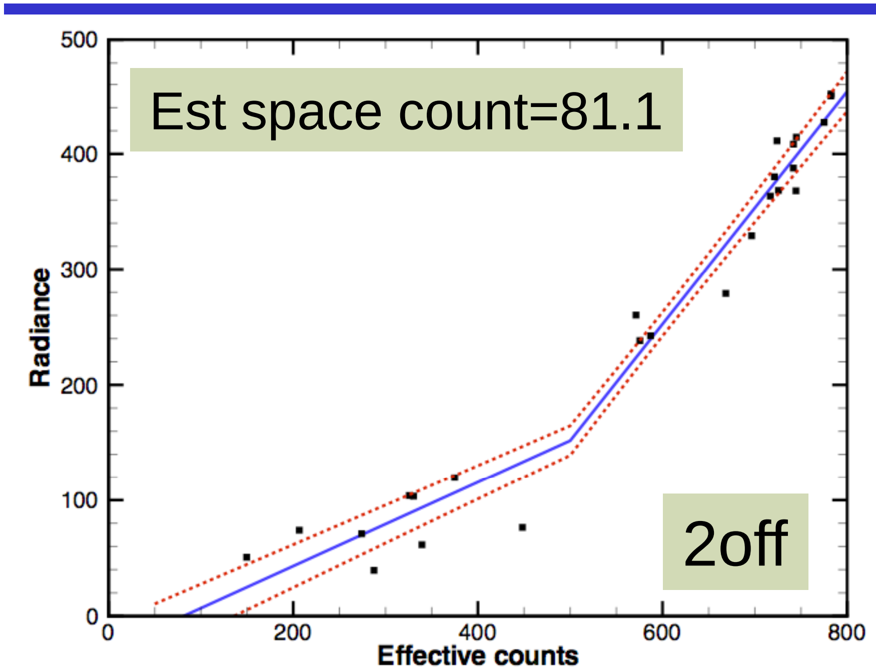
4cof, (2 independent lines)

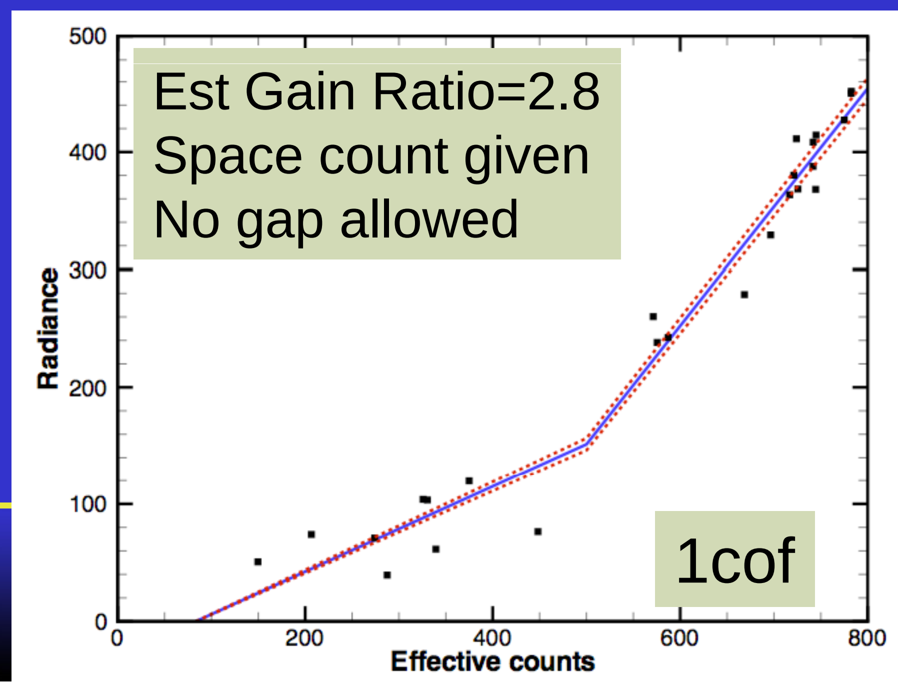
• Estimated gain ratio=7.2, radiance gap = 55.4, space count=-262.7
• prescribed gain ratio=2.8, radiance gap = 0.0, space count=83.3

Gain ratio=2.8, radiance gap = 0.0, space count=83.3









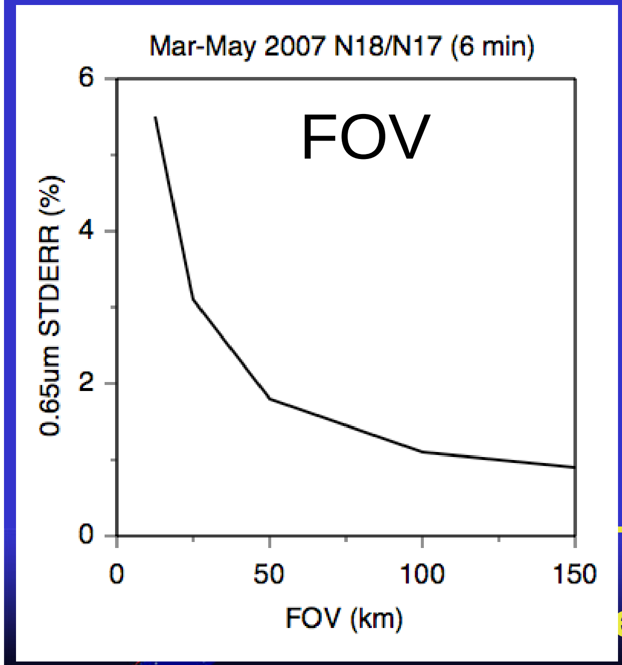
AVHHR/3 Regression Strategy

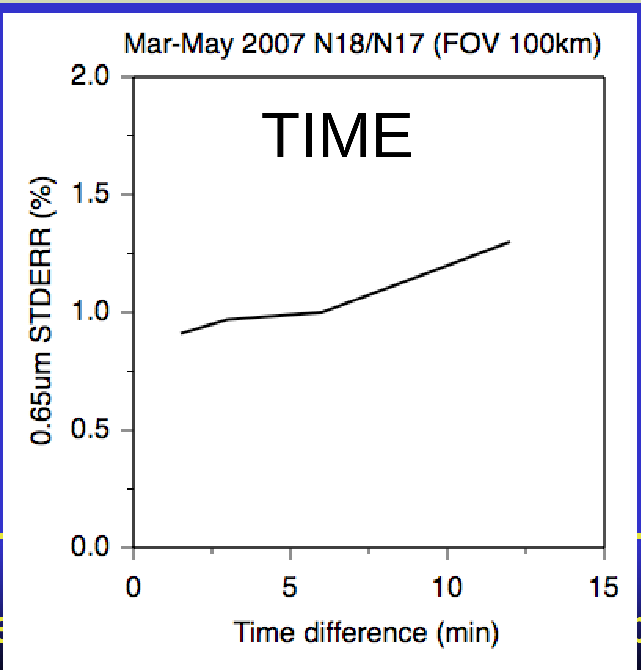
- Using monthly scatter plots, employ the 2 degree of freedom regressions to isolate the space count, breakpoint radiance gap, or gain ratios
  - Make adjustments if necessary
- Monitor 1COF regressions over time to quantify monthly noise and determine degradation
  - 1COF with one degree of freedom has a small uncertainty at the 95% confidence limit
- Validate AVHRR calibration with nominal (pre-launch) and direct MODIS/AVHRR (polar) comparisons

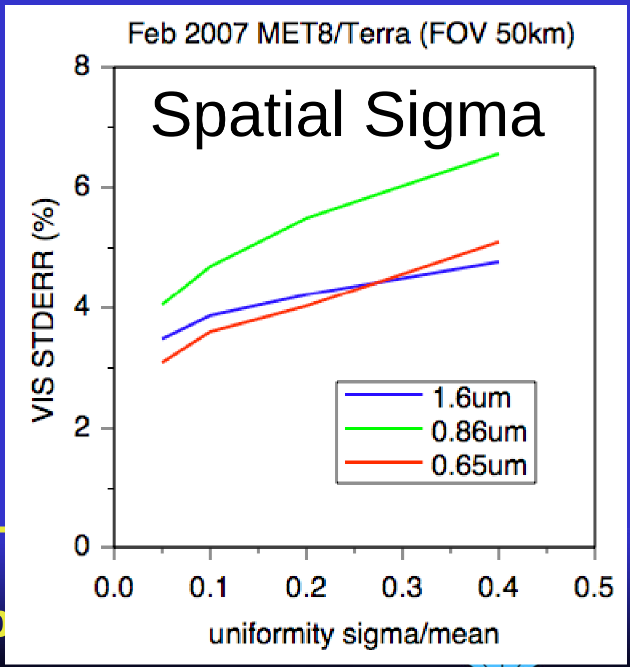
Cross-Calibration Method

- Match mean radiance or count within a 0.5° region (50km)
  - Scattering angle within 10°, < 10 minutes, no sunglint, normalize to common SZA and solar constant, and 0.2 spatial sigma threshold
- Perform monthly linear regressions to derive gain
- Compute degradation from a time line of monthly gains

Visible standard error (%) as a function of

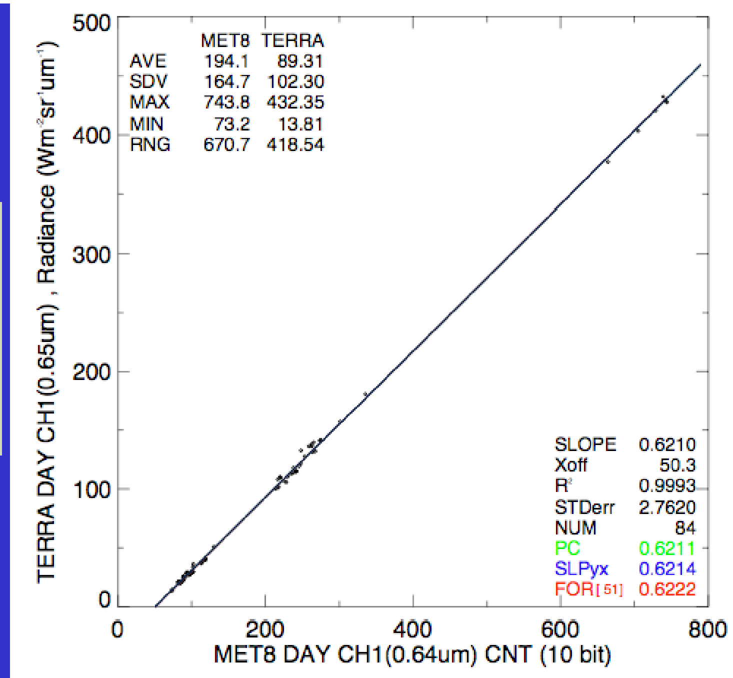






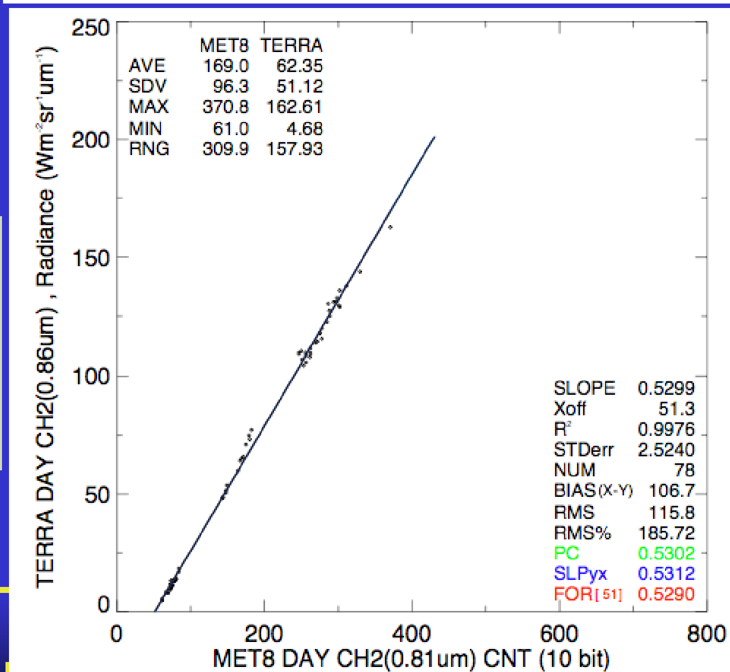
MET-8/Terra-MODIS Feb 07

0.65µm



MODIS 0.86µm saturates

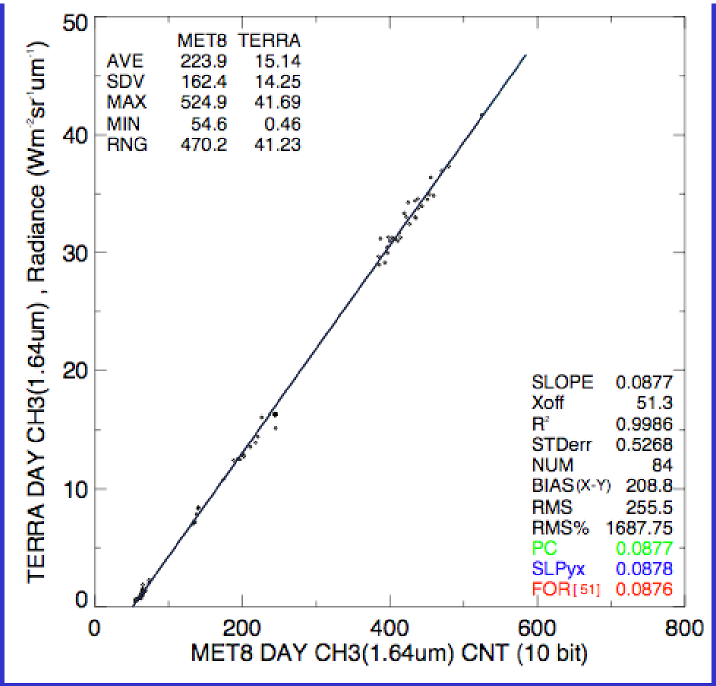
0.86µm



- 5% FOV sdev used
- further uniformity reduction results in loss of dynamic range

MET-8/Terra-MODIS Feb 07

1.64µm

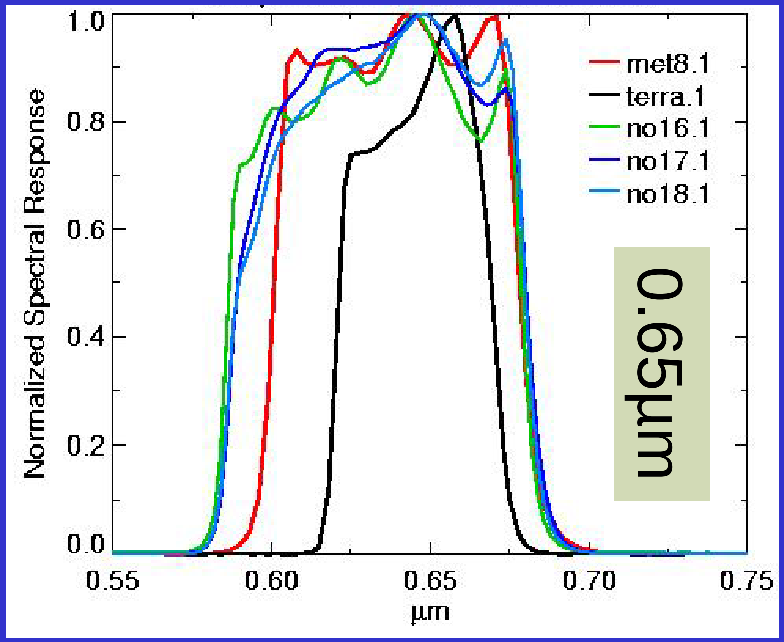


Comparison of Met-8 gains (stderr%) compared with EUMETSAT

Channel	Feb07	EUMETSAT
0.65µm	0.62 (3.1%)	0.59
0.86µm	0.53 (4.1%)	0.45
1.64µm	0.88 (3.5%)	0.88

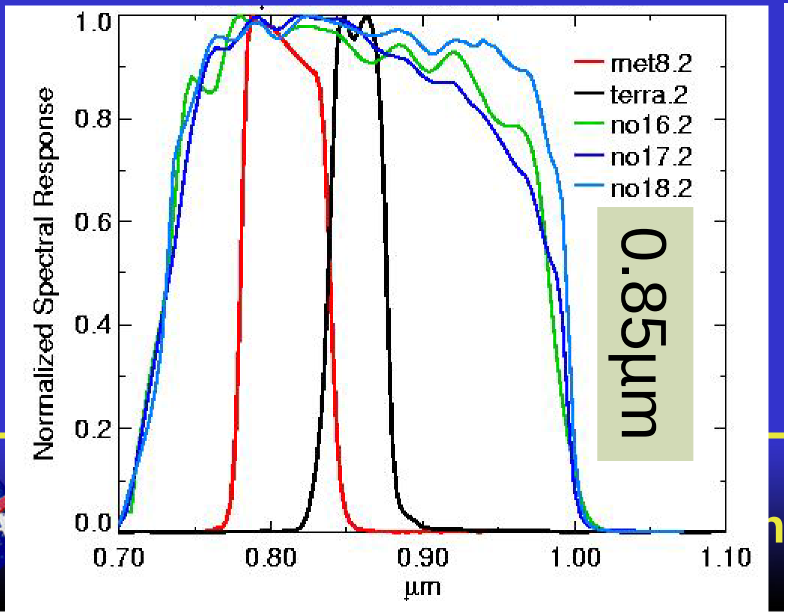
- 0.65µm Theoretical spectral correction = .9741 MET8/Terra
- 0.62*.9741=0.60
- Within 2% of EUMTETSAT

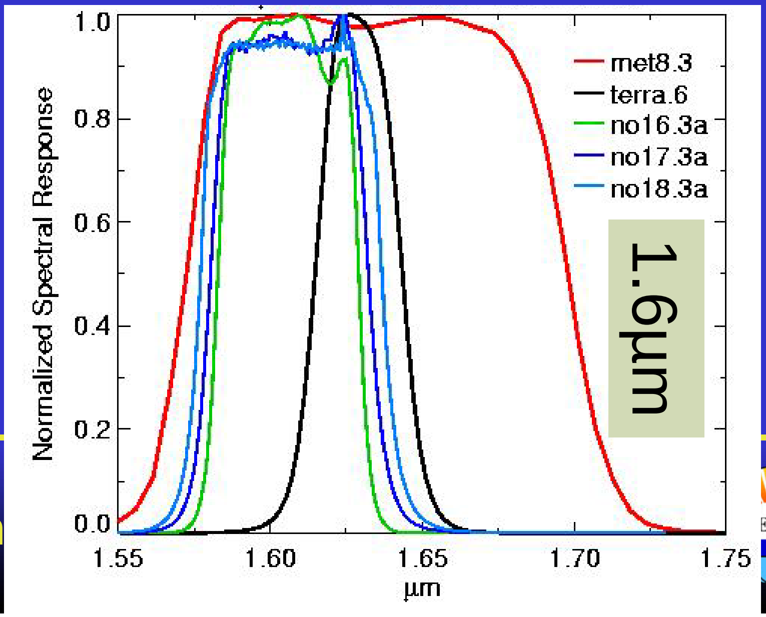
Spectral Response Functions



- No attempt is made for normalizing spectral response functions

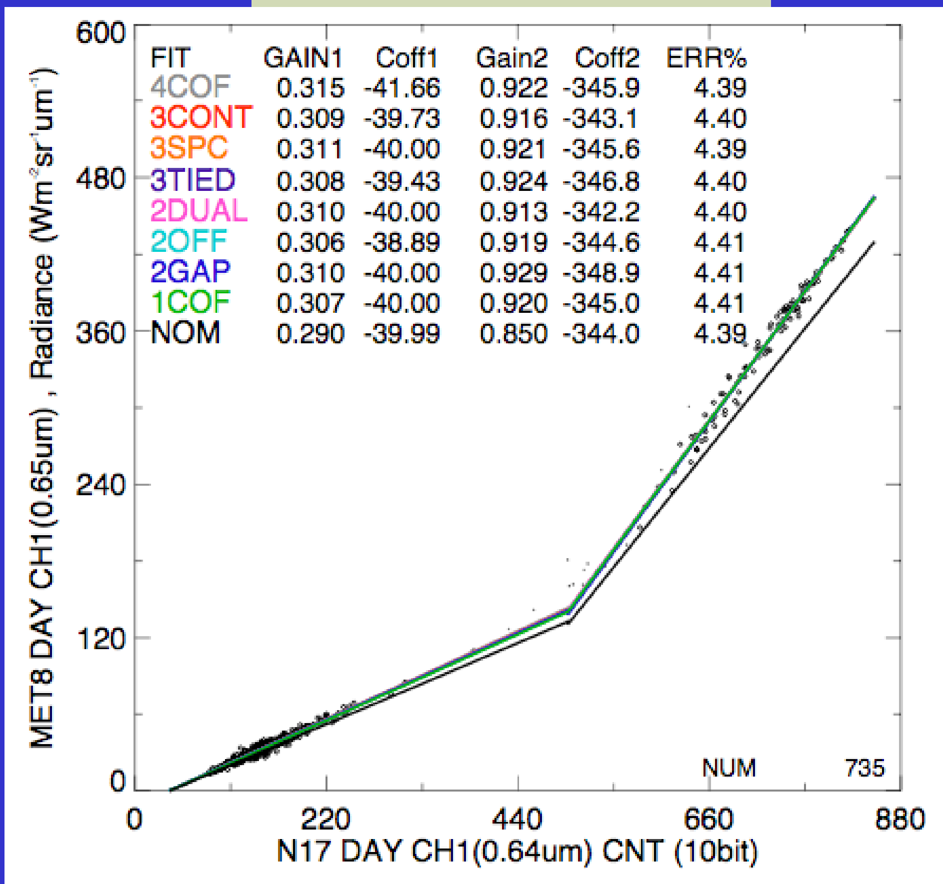
- MET8 and AVHRR most similar in the 0.65µm channel, however there are ozone absorption differences
- Note very little overlap between MET8 and AVHRR in the 0.86µm channel



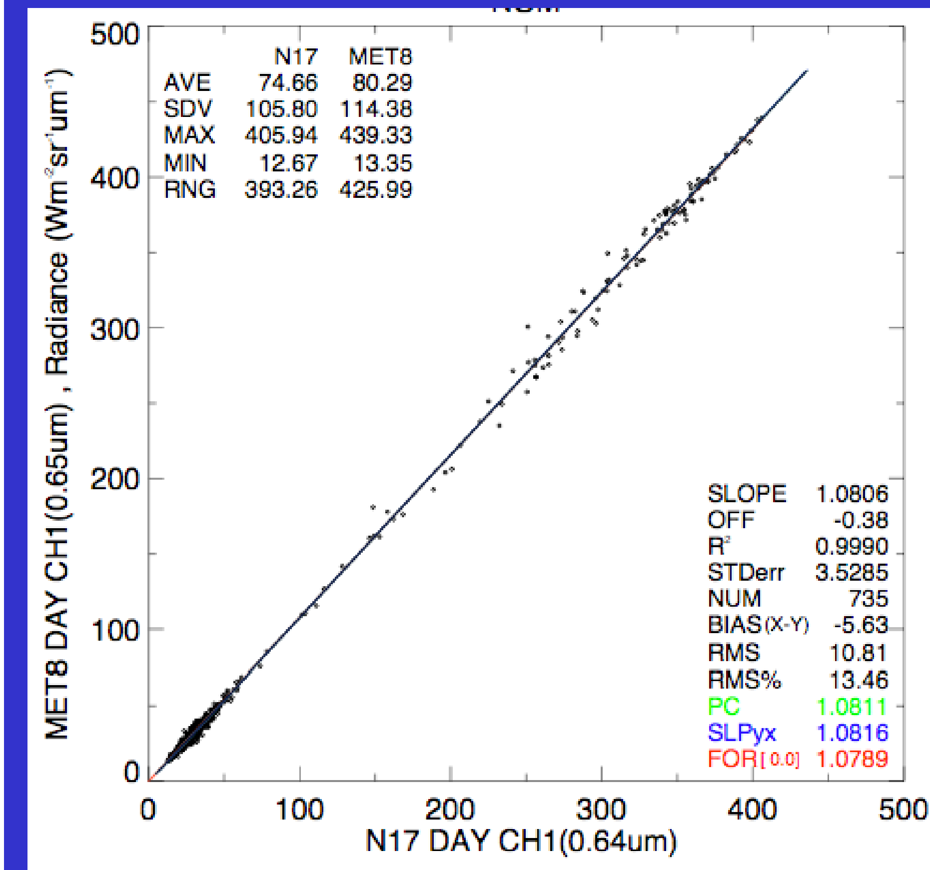


MET8/NOAA-17, Feb07, 0.65µm

NOAA-17 counts



NOAA-17 nominal radiance

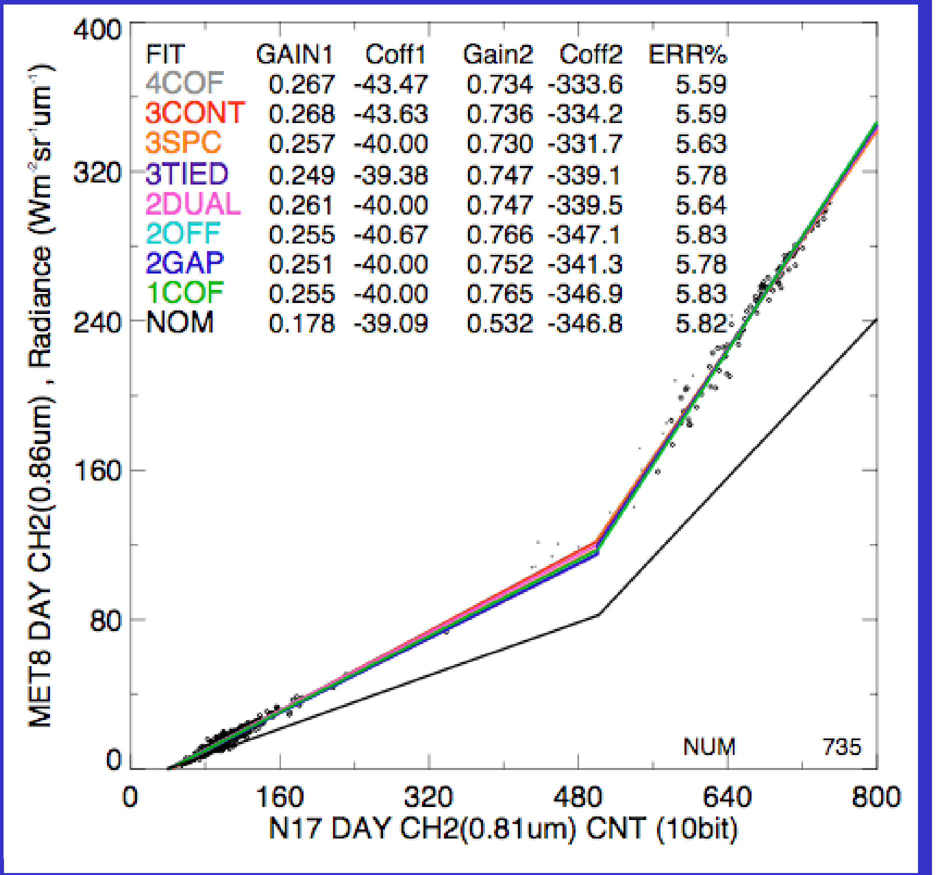


- Gray (mixed) points are where either high or low counts < 97%

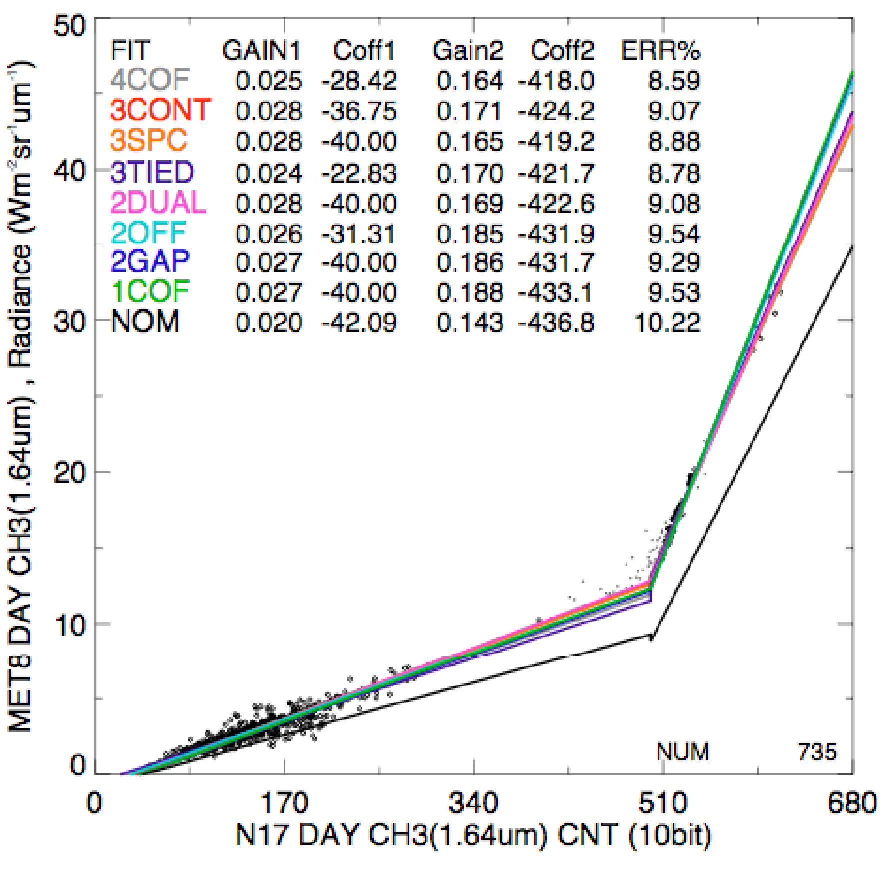
- The gain has degraded 8% from nominal compared to MET8/MODIS after 5 years in orbit

MET8/NOAA-17, Feb07

0.86µm



1.64µm



- 44% degradation with MET8/MODIS
- 27% degradation with EUMETSAT

- 31% degradation with MET8/MODIS

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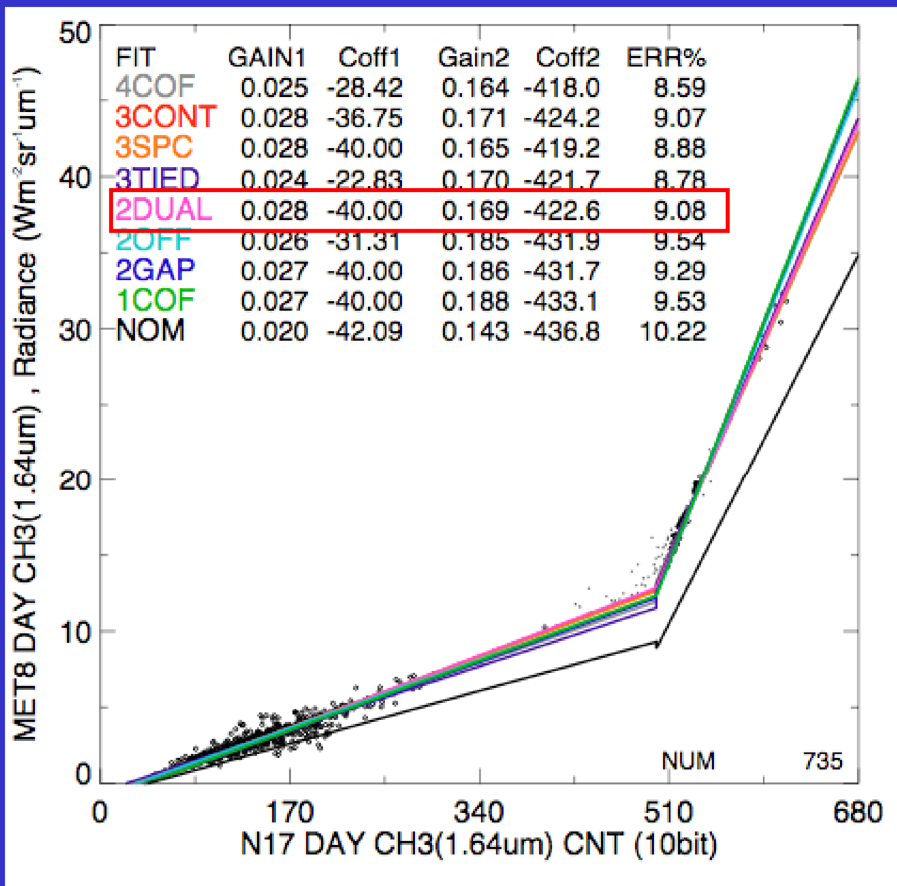
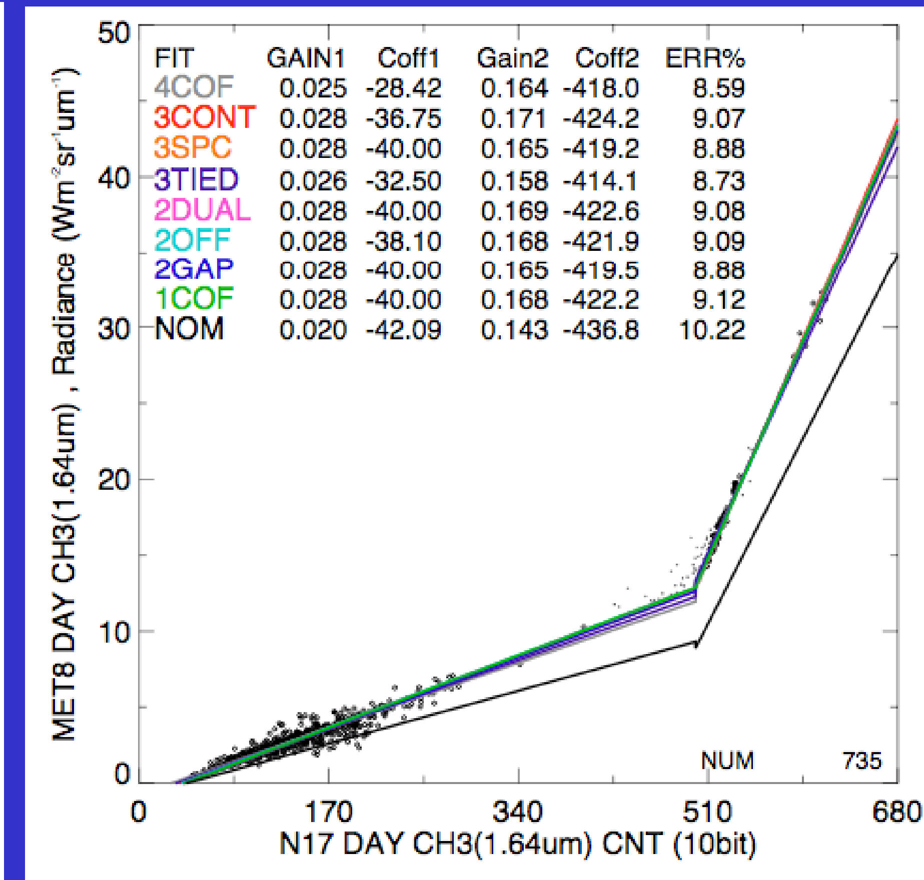
Example of gain ratio adjustment

Nominal gain ratio=7



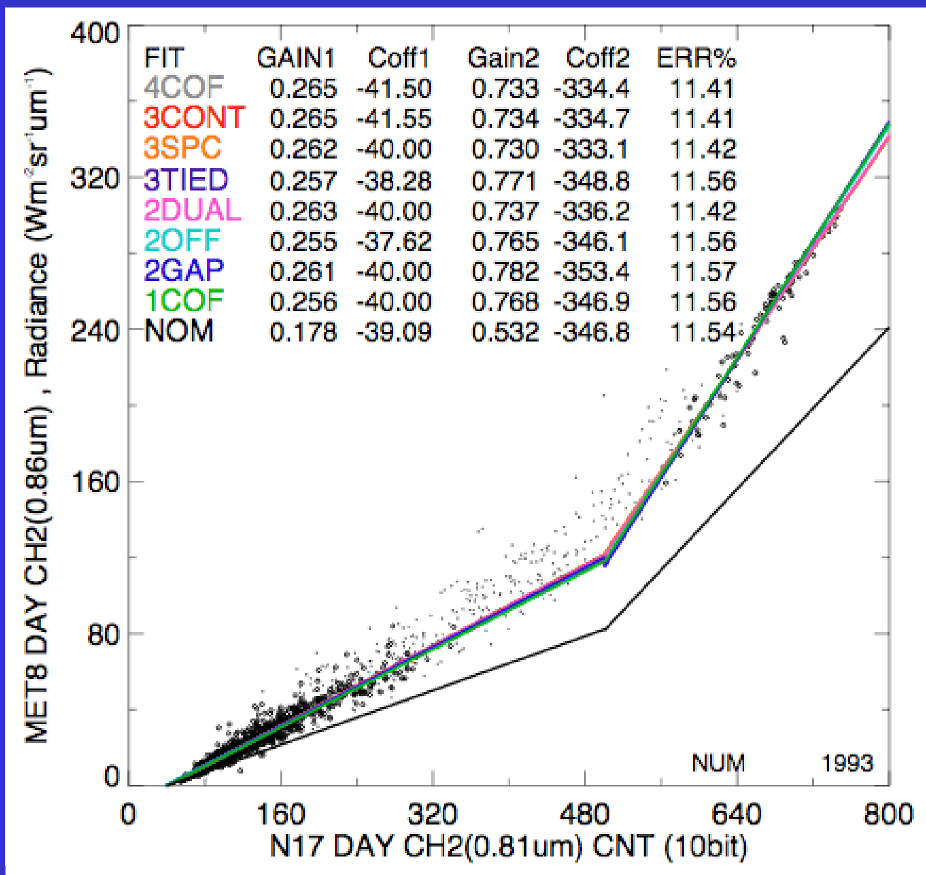
Gain Ratio=6.0



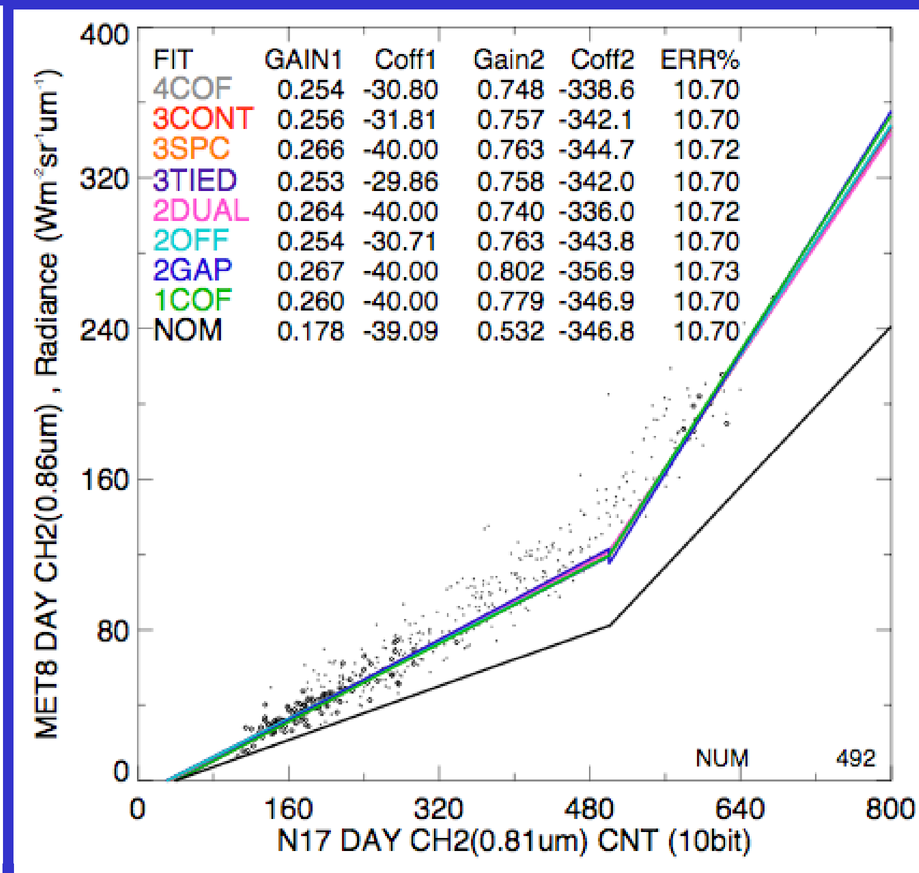
- 5% standard error reduction changing gain ratio from 7 to 6

Effect of mixed low/high count FOV
Feb07, 0.86µm, no FOV sdev threshold

All FOVs



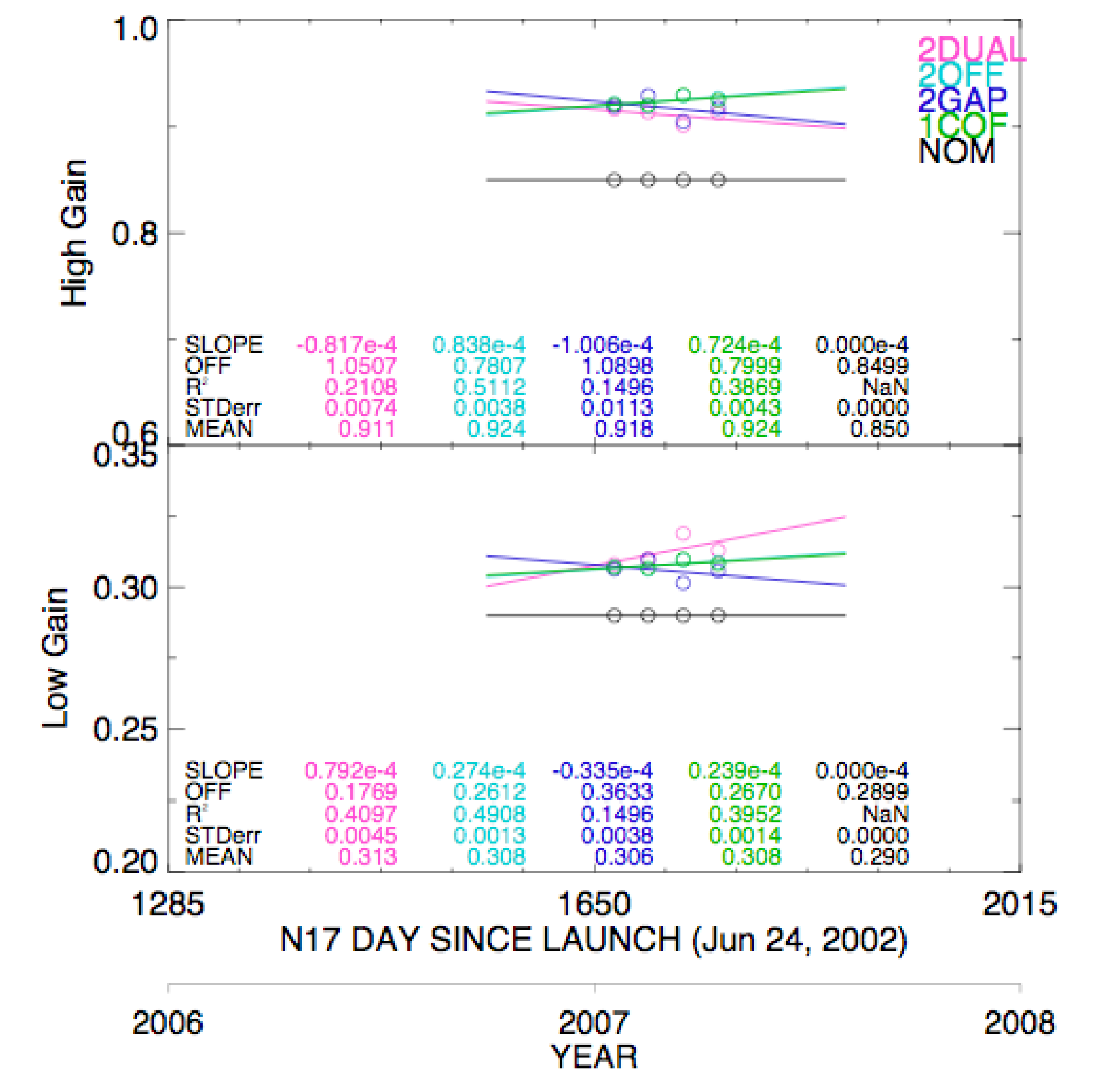
Mixed FOVs



- Gray (mixed) FOVs are where either high or low counts < 97%

- Only mixed FOVs < 97%
- All regression gains within 2%

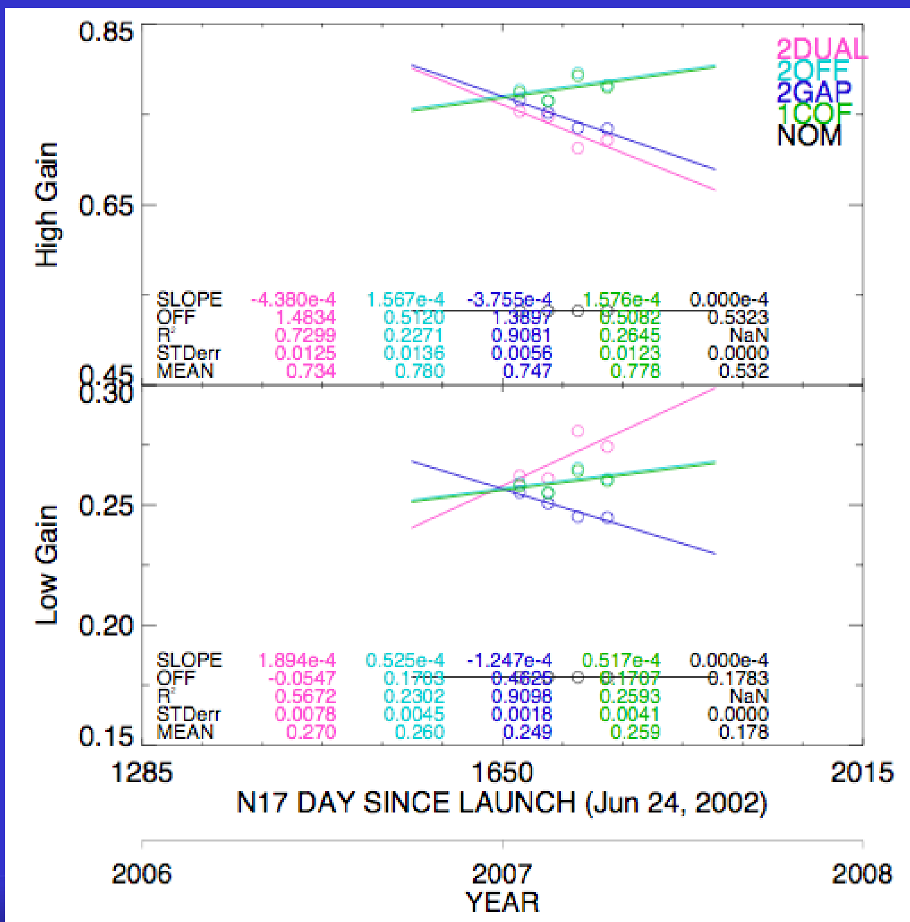
Monitor dual gains over time
Jan07-Apr07, 0.65µm, MET8/N17



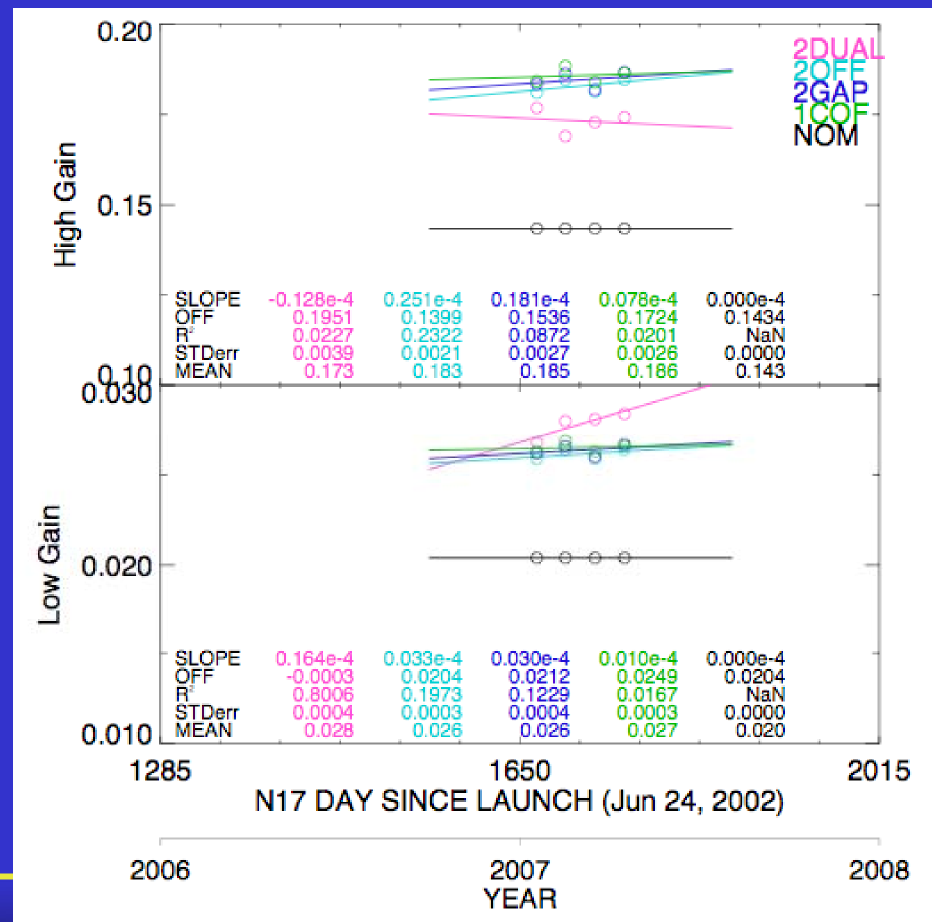
- would rely on 1COF for timeline given smallest gain uncertainty

Monitor dual gains over time
Jan07-Apr07, MET8/N17

0.86µm



1.64µm



Conclusions

- NOAA-17 AVHRR visible channels have been calibrated against MET-8/MODIS using dual gain regressions based on 50 km FOV.
  - Method can be used with CLARREO and AVHRR
  - Method able to determine both gains simultaneously
- MODIS/MET-8 calibration are very similar to EUMETSAT except the 0.86µm due to MODIS saturation

Future Work

- Complete following timelines from present to Sep 2002
  - NOAA-17/MET-8
  - MET-8/Aqua-MODIS
  - NOAA-17/Aqua-MODIS
- Validate calibration by performing 3-way cross calibration
  - NOAA-17/MET-8 * MET-8/Aqua-MODIS = NOAA-17/Aqua-MODIS
- Possibly perform sequence on GOES-10/11 for the 0.65µm channel